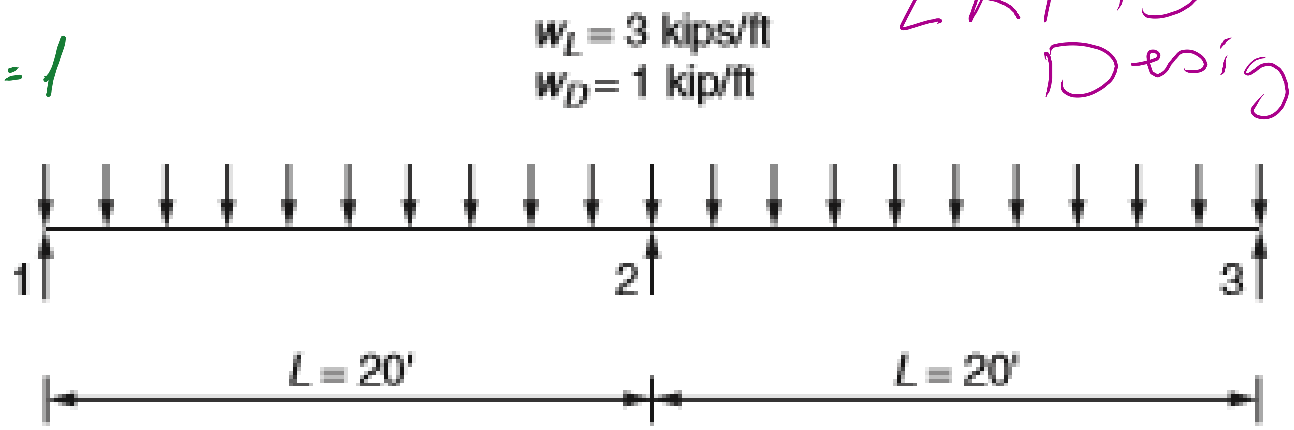
ALAN Williams

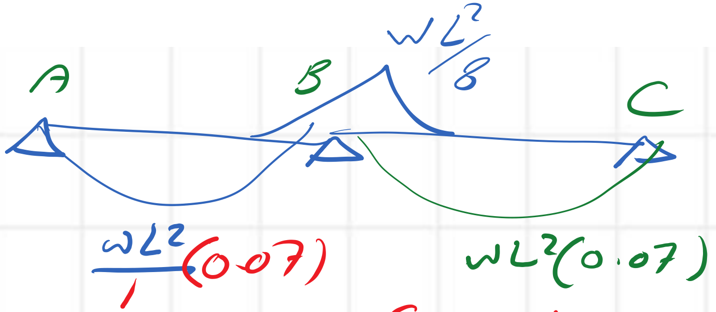
Example 4.15. Moment Redistribution

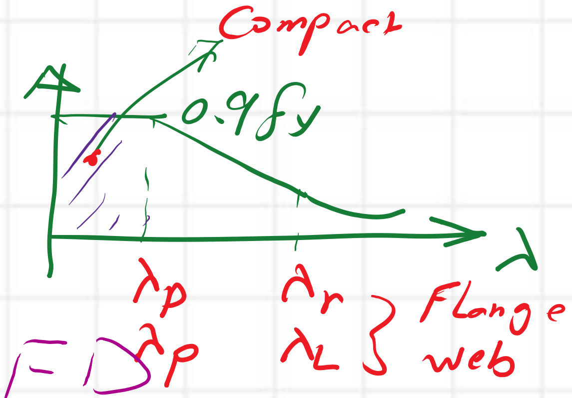
The uniform distributed loading, including the beam self-weight, acting on a two span continuous beam is shown in Fig. 4.16. Continuous lateral support is provided to the beam. Determine the lightest adequate W10 section, using steel with a yield stress of 50 ksi.

LRFD Design

$C_b = 1$







Assume the section is compact } Given

$F_y = 50$ ksi

$w_D = 1$ K/F

$w_L = 3$ K/F

Choose

$w_{ult} = \max(1.4\, w_D,\ (1.2\, D + 1.6\, L))$

LRFD

$1.2\, w_D = 1.2$ } 6 K/L

$+1.6\, w_L = 4.8$

$1.4\, w_D : 1.4$ K/L

Prepared by Eng.Maged Kamel.

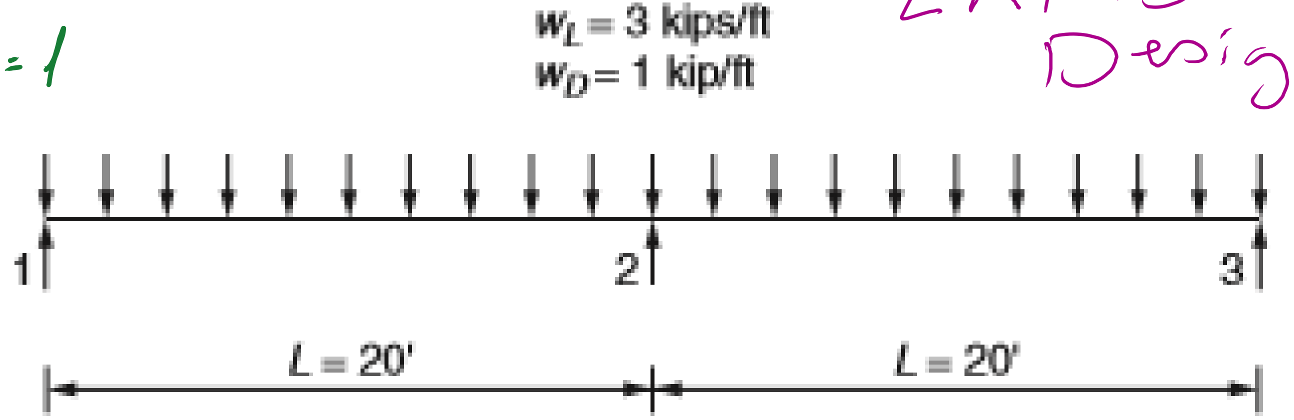
ALAN Williams

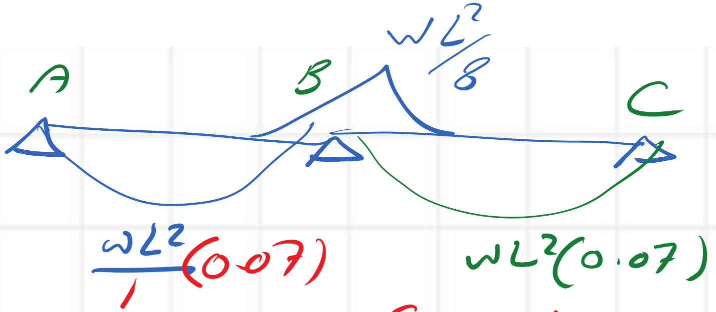
Example 4.15. Moment Redistribution

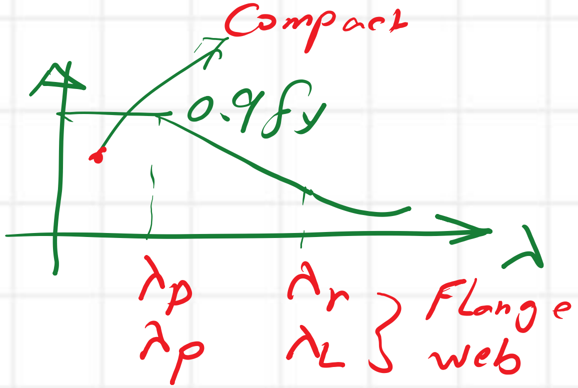
The uniform distributed loading, including the beam self-weight, acting on a two span continuous beam is shown in Fig. 4.16. Continuous lateral support is provided to the beam. Determine the lightest adequate W10 section, using steel with a yield stress of 50 ksi.

LRFD Design

$C_b = 1$





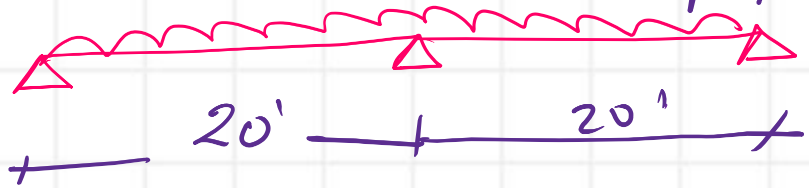


Assume the section is Compact

W_{ult} = 6 kips/Ft

Find M_{-ve}, M_{+ve} Values

Select W_{UL} = 6.00 kips/FT



Prepared by Eng.Maged Kamel.

CM #15 Page 3-207

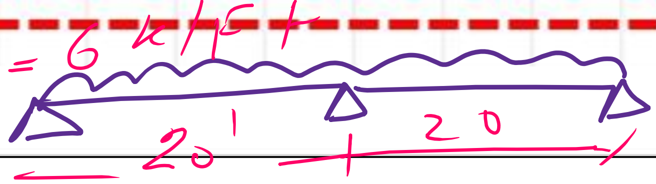


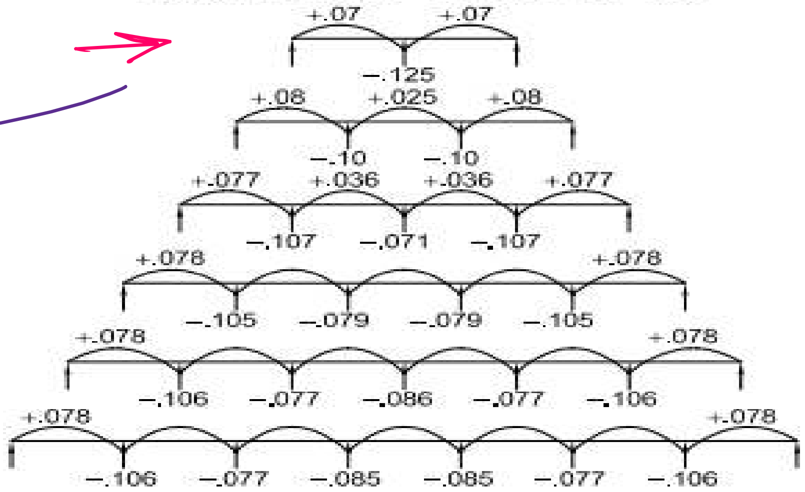
Table 3-22c
Continuous Beams
Moments and Shear Coefficients—Equal Spans, Equally Loaded

Uniform Load

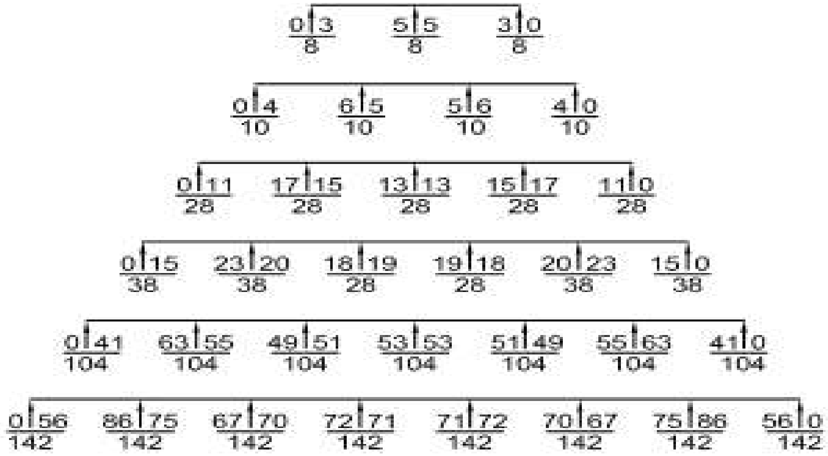
+ve 0.07

0.125 -ve

Moment in terms of wl^2



Shear in terms of wl



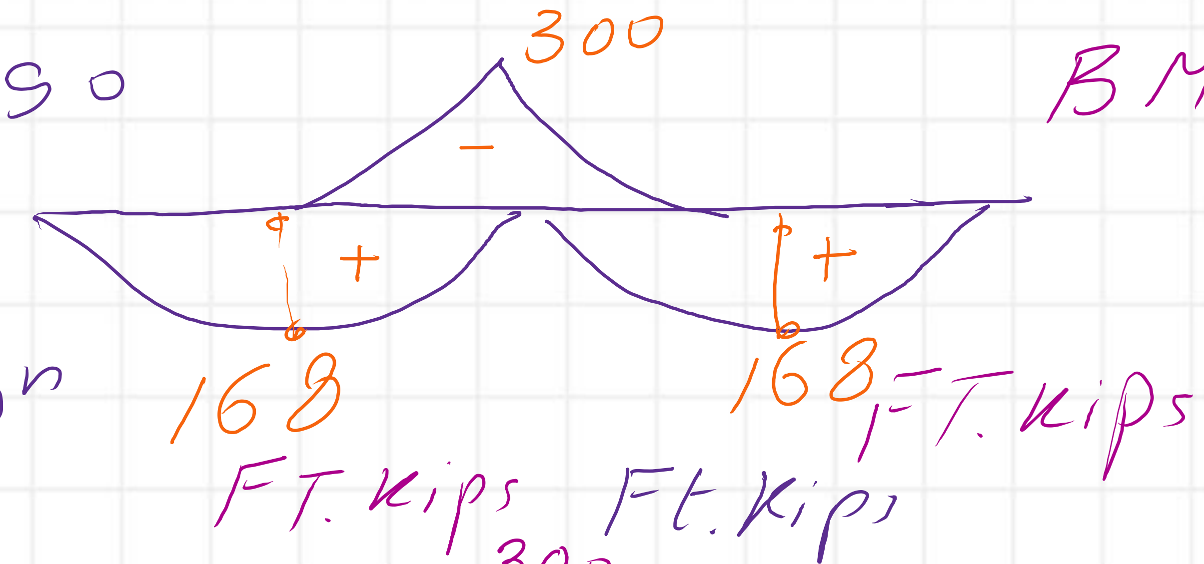
$$M_{ult}\ -ve = W_{UL}(\ell^2)(-0.125) = 6(20)^2(-0.125) = -300 \text{ FT.kips}$$

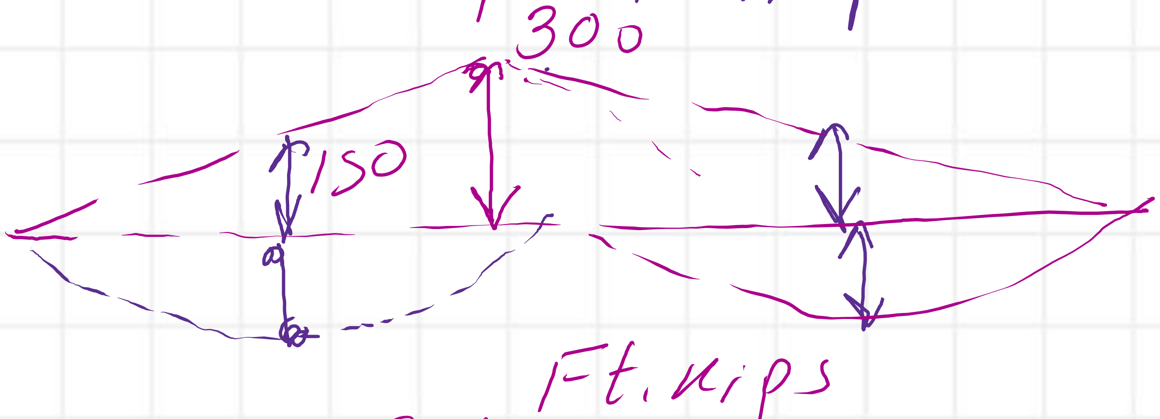
$$M_{ult}\ +ve = W_{UL}\,L^2(+0.07) = 6(20)^2(+0.07) = +168 \text{ FT.kips}$$

Prepared by Eng.Maged Kamel.

$\phi = 0.90$

LRFD Design





BM in the Tension side

Prior to redistribution

Reduce 10%

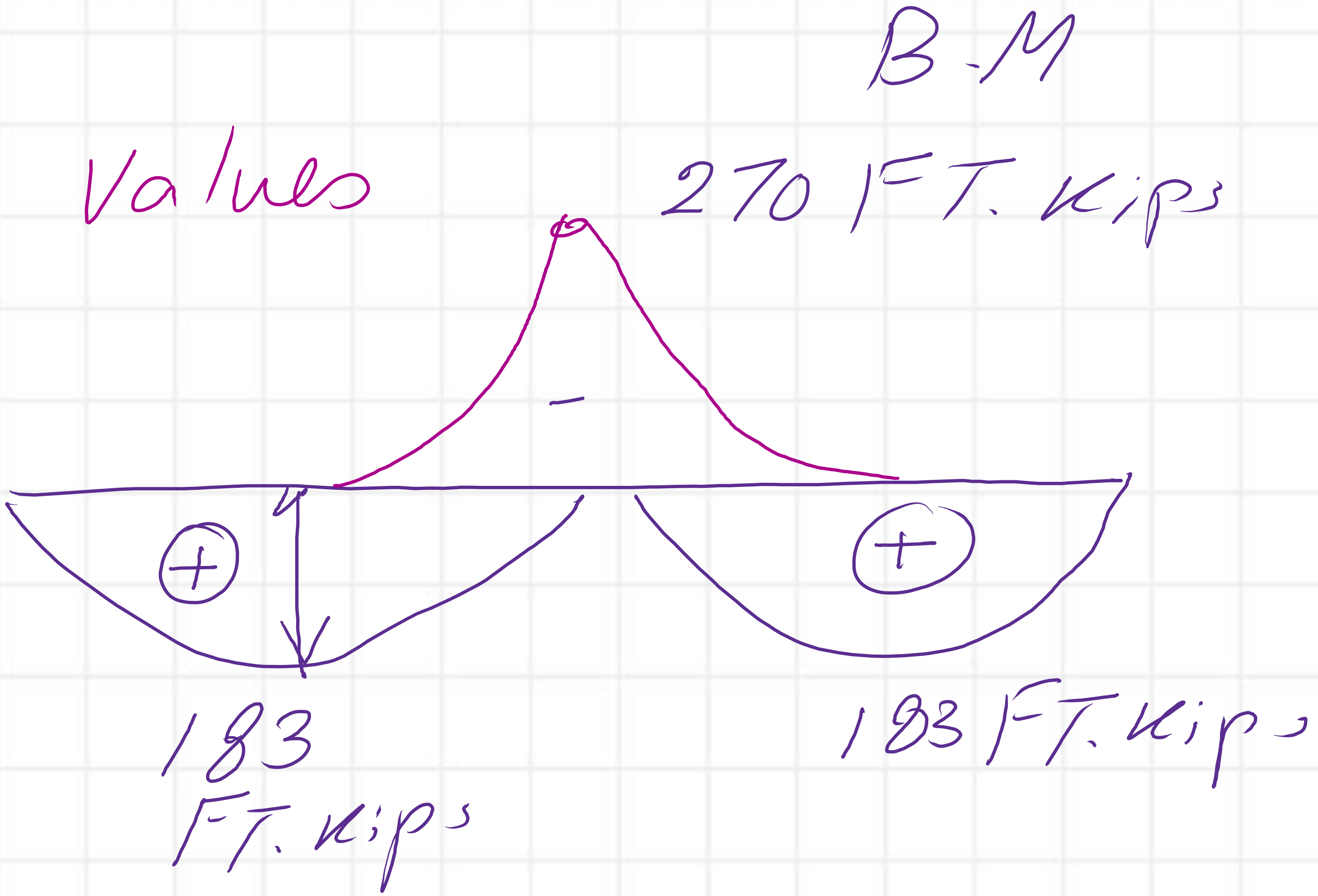
$(0.1)(300) = 30$ FT.kips

Final $M_{-ve} = 300 - 30 = 270$ FT.kips

add 10% of (150) to ⇒ 168 FT.kips

$15 + 168 = 183$ FT.kips

Final Values



After redistribution of moment

LRFD Design

M_{ult} For Design = 270 FT. kips $\phi_b = 0.90$

$M_{ult} \leq \frac{M_n}{\phi}$ => but $M_n = Z_x F_y$

Let $Z_x F_y = \phi M_{ult}$ $Z_x (50) = 0.90(270)(12)$ inch. kips

$Z_{x\,req} = 58.32$ inch^3

Z_x Table 3-2 (continued) W-Shapes Selection by Z_x $F_y = 50$ ksi												
Shape	Z_x	M_{px}/Ω_b	$\phi_b M_{px}$	M_{rx}/Ω_b	$\phi_b M_{rx}$	BF/Ω_b	$\phi_b BF$	L_p	L_r	I_x	V_{nx}/Ω_v	$\phi_v V_{nx}$
		kip-ft	kip-ft	kip-ft	kip-ft	kips	kips				kips	kips
	in.^{3}	ASD	LRFD	ASD	LRFD	ASD	LRFD	ft	ft	in.^{4}	ASD	LRFD
W18×40	78.4	196	294	119	180	8.94	13.2	4.49	13.1	612	113	169
W14×48	78.4	196	294	123	184	5.09	7.67	6.75	21.1	484	93.8	141
W12×53	77.9	194	292	123	185	3.65	5.50	8.76	28.2	425	83.5	125
W10×60	74.6	186	280	116	175	2.54	3.82	9.08	36.6	341	85.7	129

Select $W_{10} \times 60$

$Z_x = 74.60$ inch^3

From Table 3-2

$Z_x > Z_{x\,req}$

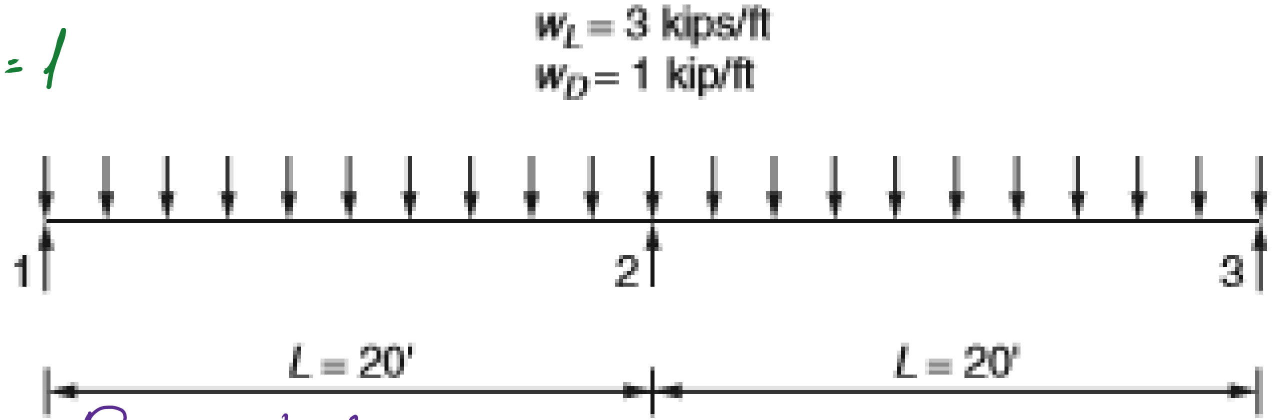
Prepared by Eng.Maged Kamel.

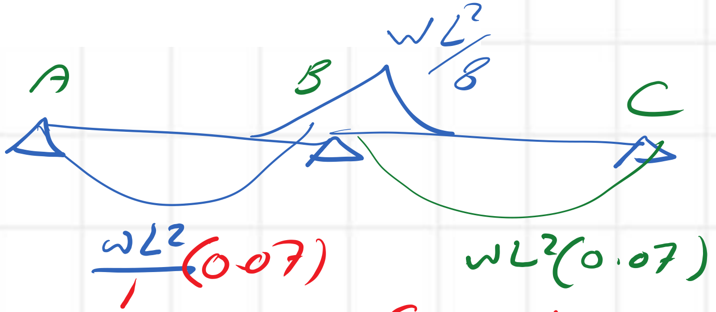
Example 4.15. Moment Redistribution

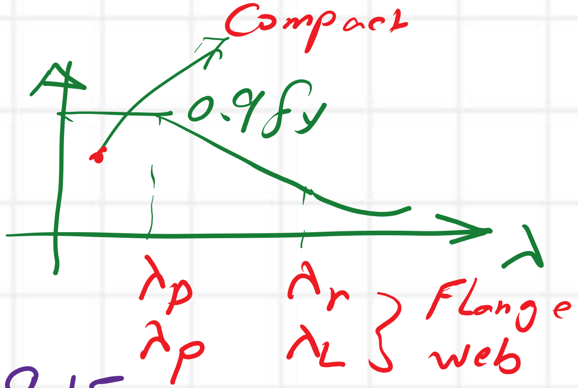
ALAN Williams LRFD

The uniform distributed loading, including the beam self-weight, acting on a two span continuous beam is shown in Fig. 4.16. Continuous lateral support is provided to the beam. Determine the lightest adequate W10 section, using steel with a yield stress of 50 ksi.

$C_b = 1$







Local Buckling

$\frac{0.38\sqrt{29000}}{\sqrt{F_y}} = \frac{65}{\sqrt{F_y \text{ ksi}}}$ $\qquad 170/\sqrt{F_y \text{ ksi}}$

Element	λ	λ_p	λ_r
Flange	$\frac{b_f}{2t_f}$	$0.38\sqrt{\frac{E}{F_y}}$	$1.0\sqrt{\frac{E}{F_y}}$
Web	$\frac{h}{t_w}$	$3.76\sqrt{\frac{E}{F_y}}$	$5.70\sqrt{\frac{E}{F_y}}$

S_x

Check Compactness

$\lambda_{pF} = 0.38\sqrt{\frac{29000}{50}} = 9.15$ → flange

$\lambda_{pW} = 3.76\sqrt{\frac{29000}{50}} = 90.55$ → web

Prepared by Eng.Maged Kamel.

L.B. Requirement

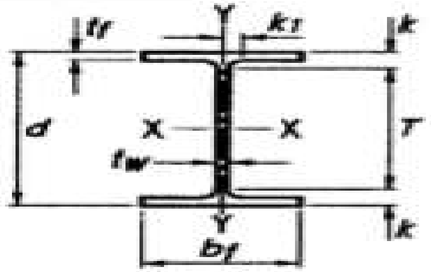
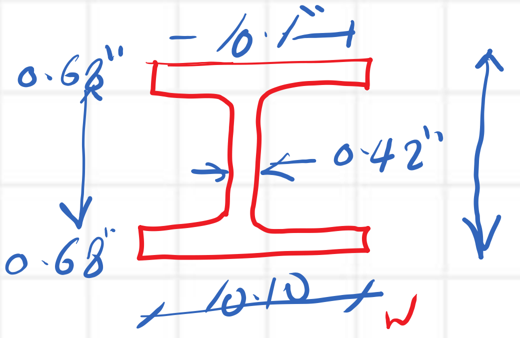


Table 1-1 (continued)
W-Shapes
Dimensions

Shape	Area, A	Depth, d		Web Thickness, t_w		Web $\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		Distance k: k_{des}	Distance k: k_{det}	Distance k_1	Distance T	Distance Workable Gage
	in.²	in.		in.		in.	in.		in.		in.	in.	in.	in.	in.
W10×112	32.9	11.4	11 3/8	0.755	3/4	3/8	10.4	10 3/8	1.25	1 1/4	1.75	1 15/16	1	7 1/2	5 1/2
×100	29.3	11.1	11 1/8	0.680	11/16	3/8	10.3	10 3/8	1.12	1 1/8	1.62	1 13/16	1		
×88	26.0	10.8	10 7/8	0.605	5/8	5/16	10.3	10 1/4	0.990	1	1.49	1 11/16	15/16		
×77	22.7	10.6	10 5/8	0.530	1/2	1/4	10.2	10 1/4	0.870	7/8	1.37	1 9/16	7/8		
×68	19.9	10.4	10 3/8	0.470	1/2	1/4	10.1	10 1/8	0.770	3/4	1.27	1 7/16	7/8		
×60	17.7	10.2	10 1/4	0.420	7/16	1/4	10.1	10 1/8	0.680	11/16	1.18	1 3/8	13/16		
×54	15.8	10.1	10 1/8	0.370	3/8	3/16	10.0	10	0.615	5/8	1.12	1 5/16	13/16		
×49	14.4	10.0	10	0.340	5/16	3/16	10.0	10	0.560	9/16	1.06	1 1/4	13/16		



$$\frac{BF}{2t_F} = \frac{10.1}{2(0.68)} = 7.43 < 9.15$$

$\frac{h}{tw} \Rightarrow h$ is $d - 2k_{des}$

h = clear distance between flanges less the corner radius at each flange

$$h = d - 2k_{des}$$

$$k_{des} = 1.18''$$

$$\frac{h}{tw} = \frac{(10.20 - 2(1.18))}{0.420} = 18.66 < 90.55$$

Prepared by Eng.Maged Kamel.

LRFD Design

Find Final ϕM_n

W10X160

$Z_x = 74.60$ inch^3

$F_y = 50$ ksi

$\phi = 0.90$

$M_{ult} = 270$ FT. kip.

$\phi F_y Z_x = 0.90(50)(74.60) = 3357$ inch. kips

$\phi M_n =$ $\frac{1}{12}$ $= 279.75$ FT. kip.

$\simeq 280$ FT. kips

$\phi M_n > M_{ult}$

$280 > 270$ FT. kips $\Rightarrow$ OK

FT. kips

Prepared by Eng.Maged Kamel.

Using Table 3-2

LRFD Design

$\phi_b M_n \approx 280$ Kips-ft ⇒ Same as Calculated

$\phi_b M_{px}$

Z_x

Table 3-2 (continued)
W-Shapes
Selection by Z_x

$F_y = 50$ ksi

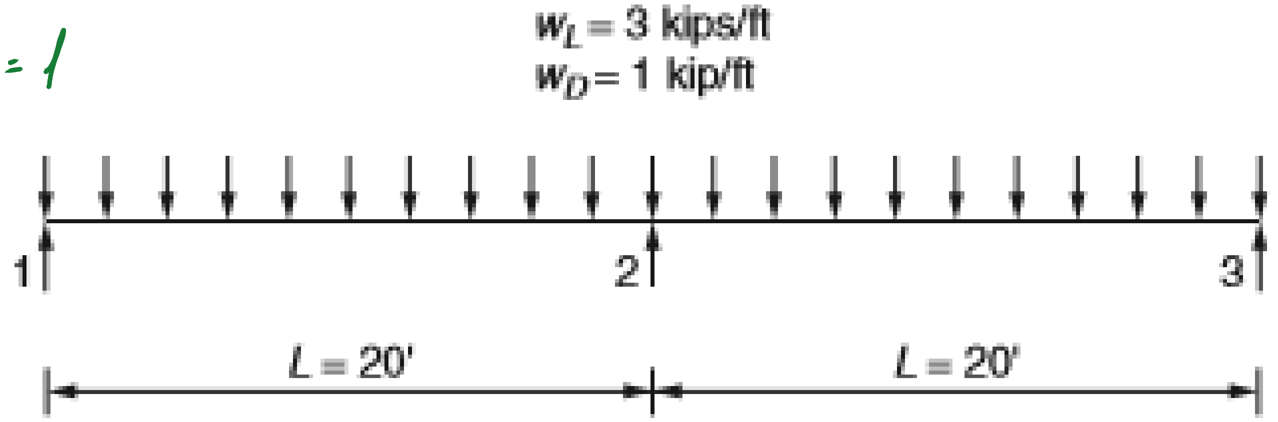
Shape	Z_x	M_{px}/Ω_b	$\phi_b M_{px}$	M_{rx}/Ω_b	$\phi_b M_{rx}$	BF/Ω_b	$\phi_b BF$	L_p	L_r	I_x	V_{nx}/Ω_v	$\phi_v V_{nx}$
		kip-ft	kip-ft	kip-ft	kip-ft	kips	kips				kips	kips
	in.^{3}	ASD	LRFD	ASD	LRFD	ASD	LRFD	ft	ft	in.^{4}	ASD	LRFD
W21×44	95.4	238	358	143	214	11.1	16.8	4.45	13.0	843	145	217
W16×50	92.0	230	345	141	213	7.69	11.4	5.62	17.2	659	124	186
W18×46	90.7	226	340	138	207	9.63	14.6	4.56	13.7	712	130	195
W14×53	87.1	217	327	136	204	5.22	7.93	6.78	22.3	541	103	154
W12×58	86.4	216	324	136	205	3.82	5.69	8.87	29.8	475	87.8	132
W10×68	85.3	213	320	132	199	2.58	3.85	9.15	40.6	394	97.8	147
W16×45	82.3	205	309	127	191	7.12	10.8	5.55	16.5	586	111	167
W18×40	78.4	196	294	119	180	8.94	13.2	4.49	13.1	612	113	169
W14×48	78.4	196	294	123	184	5.09	7.67	6.75	21.1	484	93.8	141
W12×53	77.9	194	292	123	185	3.65	5.50	8.76	28.2	425	83.5	125
W10×60	74.6	186	280	116	175	2.54	3.82	9.08	36.6	341	85.7	129

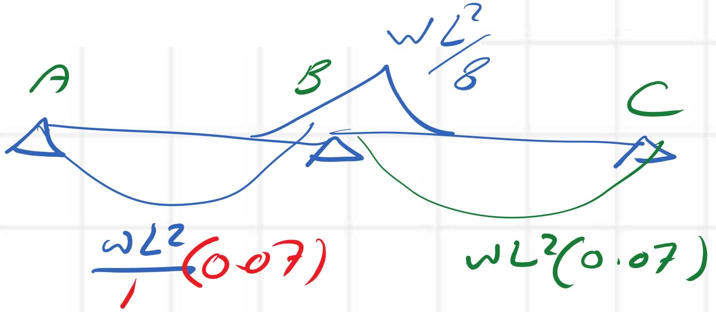
$\phi_b M_n$

Example 4.15. Moment Redistribution

The uniform distributed loading, including the beam self-weight, acting on a two span continuous beam is shown in Fig. 4.16. Continuous lateral support is provided to the beam. Determine the lightest adequate W10 section, using steel with a yield stress of 50 ksi.

$C_b = 1$



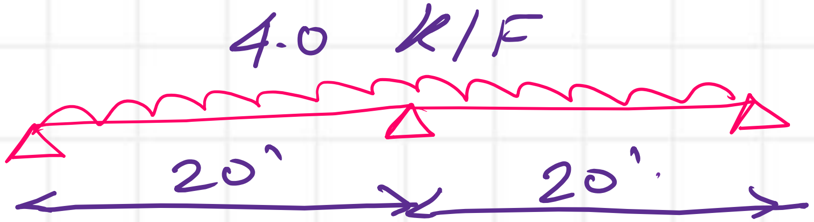


ASD Design

Assume the section is Compact

$w_T = w_D + w_L = 1.00 + 3.00 = 4$ K/F

only one Case of Loading

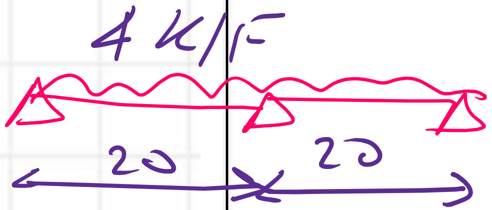


Prepared by Eng.Maged Kamel.

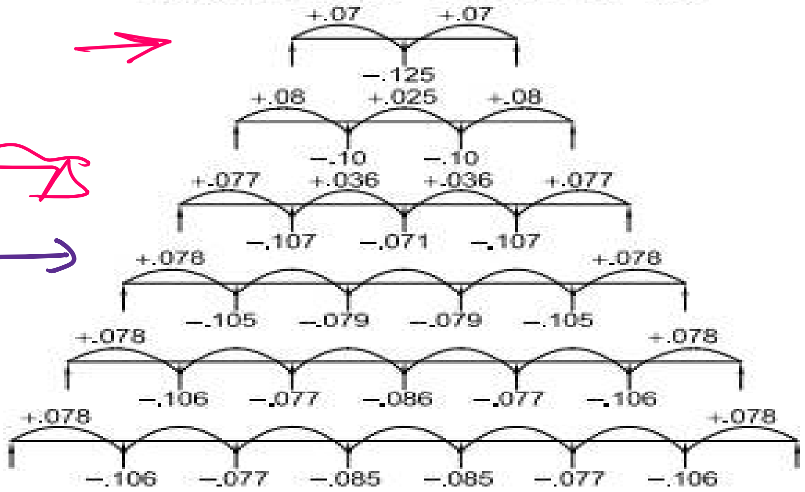
CM #15 Page 3-207 ASD

Table 3-22c
Continuous Beams
Moments and Shear Coefficients—Equal Spans, Equally Loaded

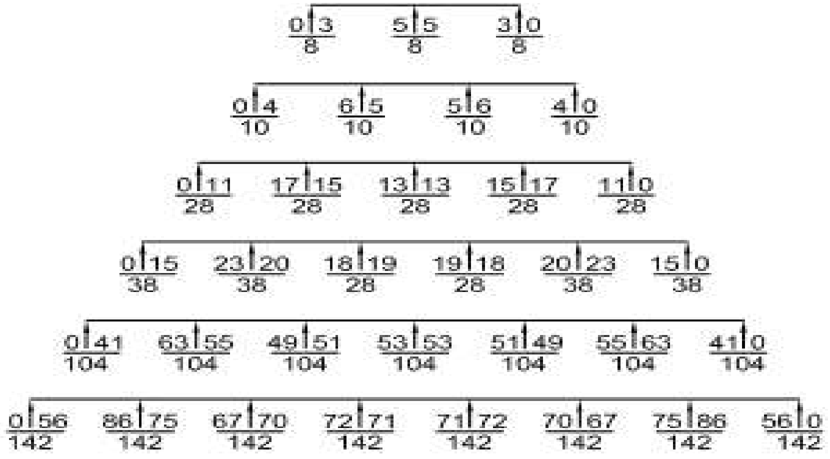
Uniform Load



Moment in terms of wl^2



Shear in terms of wl



M_{ult} −ve $= w_T(l^2)(-0.125) = 4(20)^2(-0.125) = 200$ FT.kips

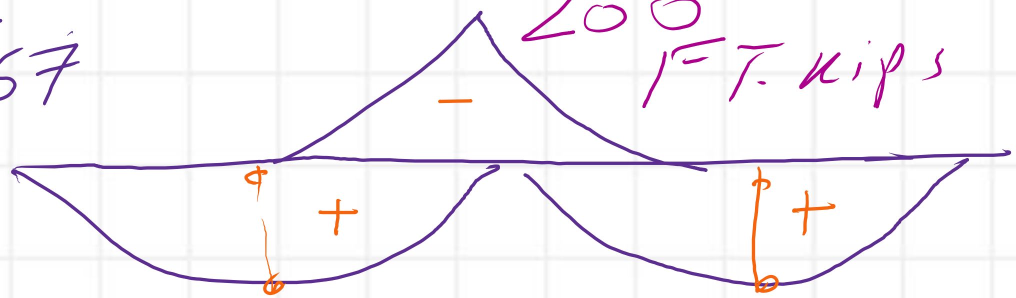
M_{ult} +ve $= w_T L^2 (+0.07) = 4(20)^2(+0.07) = 112$ FT.kips

Prepared by Eng.Maged Kamel.

ASD

$\Omega = 1.67$

200 FT.kips BM in the Tension side

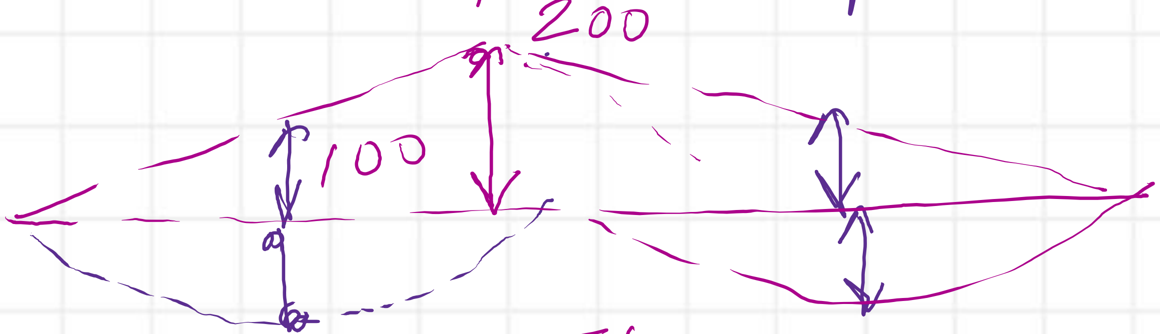


112 FT.kips 112 FT.kips

Prior to redistribution

Reduce 10%

$(0.1)(200)$



Ft.kips

Final M-ve

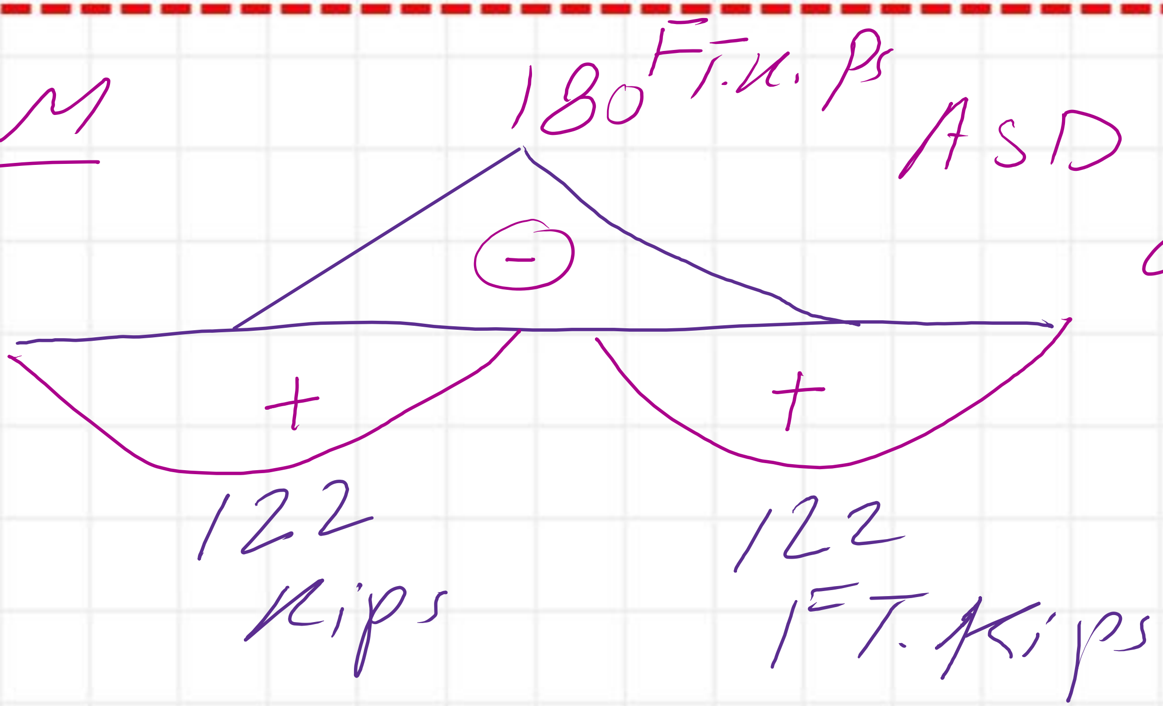
$= 200 - 20$

$= 180$ FT.kips

add 10% of (100) = 10 FT.kips

$10 + 112 = 122$ FT.kips

B.M



ASD Design after redistribution

$\Omega = 1.67$

$M_{max} = 180$ FT.kips

ASD Design

$F_y = 50$ ksi; $\Omega_b = 1.67$

M_T for Design = 180 FT. kips

$M_T \le \frac{M_n}{\Omega}$ => but $M_n = Z_x F_y$

Let $Z_x F_y = M_T \Omega$

$Z_x (50) = 1.67 (180)(12)$ inch . kips

$Z_x = 72.144$ inch^3

Select $W_{10} \times 60$

$Z_x = 74.60$ inch^3

From Table 3-2

$Z_{x\,selected} > Z_{x\,req}$

Z_x — Table 3-2 (continued) W-Shapes Selection by Z_x — $F_y = 50$ ksi

Shape	Z_x	M_{px}/Ω_b	$\phi_b M_{px}$	M_{rx}/Ω_b	$\phi_b M_{rx}$	BF/Ω_b	$\phi_b BF$	L_p	L_r	I_x	V_{nx}/Ω_v	$\phi_v V_{nx}$
	in.^{3}	kip-ft ASD	kip-ft LRFD	kip-ft ASD	kip-ft LRFD	kips ASD	kips LRFD	ft	ft	in.^{4}	kips ASD	kips LRFD
W18×40	**78.4**	**196**	294	**119**	180	**8.94**	13.2	**4.49**	**13.1**	**612**	**113**	169
W14×48	78.4	196	294	123	184	5.09	7.67	6.75	21.1	484	93.8	141
W12×53	77.9	194	292	123	185	3.65	5.50	8.76	28.2	425	83.5	125
W10×60	74.6	186	280	116	175	2.54	3.82	9.08	36.6	341	85.7	129

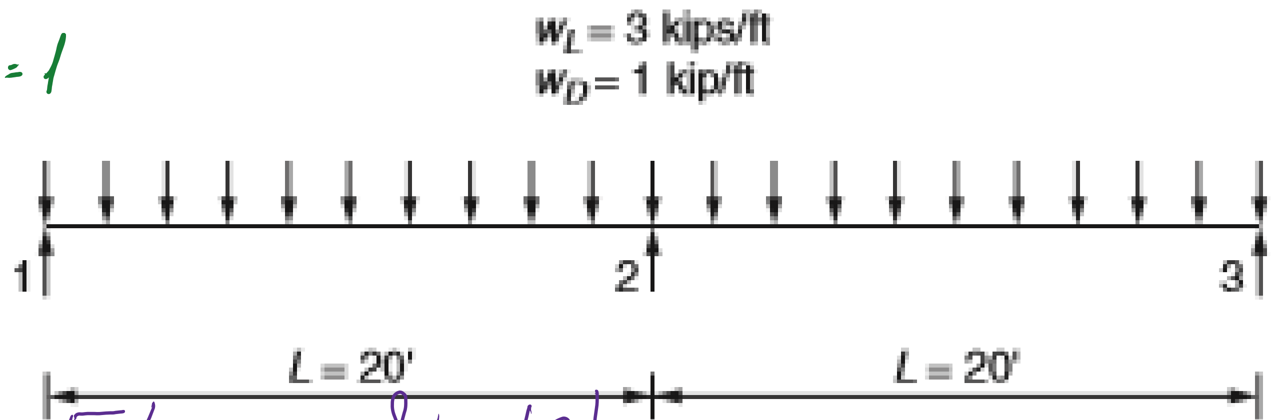
Prepared by Eng.Maged Kamel.

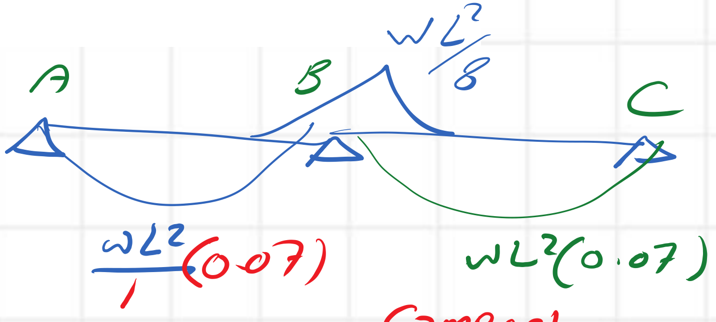
ASD Design

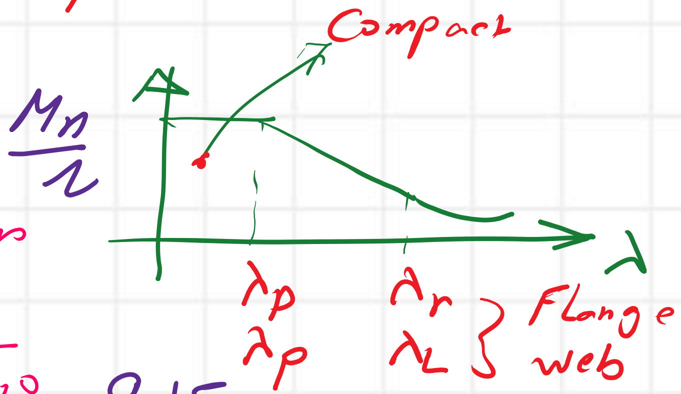
Example 4.15. Moment Redistribution

The uniform distributed loading, including the beam self-weight, acting on a two span continuous beam is shown in Fig. 4.16. Continuous lateral support is provided to the beam. Determine the lightest adequate W10 section, using steel with a yield stress of 50 ksi.

$C_b = 1$







L.B Flange & web

$\frac{0.38\sqrt{29000}}{\sqrt{F_y}} = \frac{65}{\sqrt{F_{y\,ksi}}}$ $\quad 170/\sqrt{F_{y\,ksi}}$

Check Compactness

Element	λ	λ_p	λ_r
Flange	$\frac{b_f}{2t_f}$	$0.38\sqrt{\frac{E}{F_y}}$	$1.0\sqrt{\frac{E}{F_y}}$
Web	$\frac{h}{t_w}$	$3.76\sqrt{\frac{E}{F_y}}$	$5.70\sqrt{\frac{E}{F_y}}$

S_x

$\lambda_{p_F} = 0.38\sqrt{\frac{29000}{50}} = 9.15$

$\lambda_{p_W} = 3.76\sqrt{\frac{29000}{50}} = 90.55$

Prepared by Eng.Maged Kamel.

Selected W10 x 60

Table 1-1

ASD Design

Check Compactness

Table 1-1 (continued)
W-Shapes
Properties

W10–W8

Nominal Wt.	Compact Section Criteria		Axis X-X				Axis Y-Y				r_{ts}	h_o	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	I	S	r	Z	I	S	r	Z			J	C_w
lb/ft			in.^{4}	in.^{3}	in.	in.^{3}	in.^{4}	in.^{3}	in.	in.^{3}	in.	in.	in.^{4}	in.^{6}
112	4.17	10.4	716	126	4.66	147	236	45.3	2.68	69.2	3.08	10.2	15.1	6020
100	4.62	11.6	623	112	4.60	130	207	40.0	2.65	61.0	3.04	10.0	10.9	5150
88	5.18	13.0	534	98.5	4.54	113	179	34.8	2.63	53.1	2.99	9.81	7.53	4330
77	5.86	14.8	455	85.9	4.49	97.6	154	30.1	2.60	45.9	2.95	9.73	5.11	3630
68	6.58	16.7	394	75.7	4.44	85.3	134	26.4	2.59	40.1	2.92	9.63	3.56	3100
60	7.41	18.7	341	66.7	4.39	74.6	116	23.0	2.57	35.0	2.88	9.52	2.48	2640
54	8.15	21.2	303	60.0	4.37	66.6	103	20.6	2.56	31.3	2.85	9.49	1.82	2320
49	8.93	23.1	272	54.6	4.35	60.4	93.4	18.7	2.54	28.3	2.84	9.44	1.39	2070

$\frac{b_f}{2t_f} = 7.41 < 9.15$

$\frac{h}{t_w} = 18.70 < 90.55 \Rightarrow$ Compare with OK

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ASD Design

Find Final ϕM_n

W10 X 60

$Z_x = 74.60$ inch^3

$F_y = 50$ ksi

$\Omega_b = 1.67$

$M_T = 180$ FT.kip.

$\frac{1}{\Omega} F_y Z_x = \frac{1}{1.67}(50)(74.60) = 2233.5$ inch.kips

1/12

$= 186.13$ FT.kip.

$\simeq 186$ FT.kips

$\frac{1}{\Omega} M_n > M_T$

186 FT.kips > 180 FT.kips $\Rightarrow$ OK

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ASD

Verify Using Table 3-2

$M_n/\Omega_b = 186.0$ kips-Ft → Same as Calculated

Z_x

Table 3-2 (continued)
W-Shapes
Selection by Z_x

$F_y = 50$ ksi

Shape	Z_x	M_{px}/Ω_b	$\phi_b M_{px}$	M_{rx}/Ω_b	$\phi_b M_{rx}$	BF/Ω_b	$\phi_b BF$	L_p	L_r	I_x	V_{nx}/Ω_v	$\phi_v V_{nx}$
		kip-ft	kip-ft	kip-ft	kip-ft	kips	kips				kips	kips
	in.³	ASD	LRFD	ASD	LRFD	ASD	LRFD	ft	ft	in.⁴	ASD	LRFD
W21×44	95.4	238	358	143	214	11.1	16.8	4.45	13.0	843	145	217
W16×50	92.0	230	345	141	213	7.69	11.4	5.62	17.2	659	124	186
W18×46	90.7	226	340	138	207	9.63	14.6	4.56	13.7	712	130	195
W14×53	87.1	217	327	136	204	5.22	7.93	6.78	22.3	541	103	154
W12×58	86.4	216	324	136	205	3.82	5.69	8.87	29.8	475	87.8	132
W10×68	85.3	213	320	132	199	2.58	3.85	9.15	40.6	394	97.8	147
W16×45	82.3	205	309	127	191	7.12	10.8	5.55	16.5	586	111	167
W18×40	78.4	196	294	119	180	8.94	13.2	4.49	13.1	612	113	169
W14×48	78.4	196	294	123	184	5.09	7.67	6.75	21.1	484	93.8	141
W12×53	77.9	194	292	123	185	3.65	5.50	8.76	28.2	425	83.5	125
W10×60	74.6	186	280	116	175	2.54	3.82	9.08	36.6	341	85.7	129

$\frac{M_n}{\Omega_b} = 186$ FT.kip

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